HIGH-RESOLUTION MAPPING OF EUROPA'S IMPACT CRATERS: COMPARISON WITH GANYMEDE. P. Schenk[1], and J.M. Moore[2], [1]Lunar & Planetary Institute, Houston, TX 77058, [2]SETI Institute, MS 245-3, NASA Ames Research Center, Moffett Field, CA 94035-1000, e-mail: schenk@lpi.usra.edu.

Introduction: Any examination of Europa's unusual impact morphologies is null and void unless detailed comparison can be made to "normal" impact craters on large icy bodies without shallow liquid water oceans. Ganymede and Callisto, with similar surface gravity, lack of recent geologic activity, and relatively deep oceans, come to mind. Here we examine the limited data available for Europan craters and begin the task of comparison with Ganymedean craters of similar size. We focus on impact melt, morphology, and topography (derived from stereo and photoclinometric (PC) analyses).

Europa. Moore et al. [1] performed the first survey of Europan impact craters. High-resolution (better than 100 m/pixel) imaging of large craters on Europa is limited to Manannan (D~23 km, res. 20 m/pixel), and Cilix (D ~19 km, res. 60 m/pixel). The Manannan high-resolution mosaic clear shows flow-like features within the crater rim and onlapping onto the pedestal ejecta deposit (Fig. 1). High-resolution stereo and PC topography (Fig. 1) shows that these features usually occupy local topographic lows, but that these features can also remain on slopes and that intervening areas are very rugged. This would seem to imply that impact melt is not especially voluminous on large Europan craters, and was not invicid.

Additional coverage of Pwyll (D~27 km) and the multiring structures Callanish (D~33 km) and Tyre (D~41 km) was obtained at 125, 170, and 50 m/pixel, respectively. Mapping of ejecta deposits [e.g., 2] shows that the nominal crater rim lies interior to the inner rings, in terrain that is essentially flat. Swirl textures on the floors of both ring structures are reminiscent of features observed in melt sheets on some lunar craters.

Ganymede. The only relatively pristine large impact crater targeted by Galileo on either Ganymede or Callisto is Melkart, a central dome crater on Ganymede (D~107 km, res. 175 m/pixel). The floor of Melkart (and other craters seen at lower resolution) is characterized by large 5-15 km wide rounded hillocks, a morphology reminiscent of melt sheets on some lunar craters. This morphology has not been recognized on Europa (granted that there are no craters this size on Europa). Unfortunately, no other large pristine "normal" impact crater was targeted for either Ganymede or Callisto.

Unusual impact landforms on Ganymede and Callisto include anomalous dome craters, penepalimpsests, and palimpsests. These impact morphologies occur at D>60 km, but generally are relatively ancient structures [3]. A radial image transect was obtained of the 207-km diameter penepalimpsest Epigeous at 90 m effective resolution (our highest such resolution). Despite the relative age of this structure (during or immediately after bright terrain emplacement), these images (Fig. 2) reveal features somewhat reminiscent of flow features seen at Manannan. Another penepalimpsest, Buto Facula (D~157 km) was imaged at too low a resolution (180 m/pixel) to reliably map floor textures. Smooth ponds of impact melt are lacking, however.

Comparisons. Europan craters do share some similarities with those on Ganymede. Evidence for rim slumping is sparse compared to lunar examples, and virtually no unequivocal terrace has been identified on any of the satellites. Evidence for flow in the ejecta on the crater floor is apparent but generally limited on all three satellites. Topographic pedestals commonly forming the inner ejecta deposit of Europan craters are similar to those found around Ganymede craters such as Achelous [e.g., 2]. Europan pedestals are often associated with dark, rather than bright material, however. Ejecta typically consists of shallow-seated excavated crustal material, suggesting that such material on Europa is relatively dark compared with the present surface.

Topography. Detailed mapping of impact crater shapes shows that impact craters follow well-defined depth-diameter (d/D) trends on all three satellites, but that Europa diverges from its sister satellites [4]. Europan craters up to D~9 km across have shapes similar to Ganymedean craters. At D > 9 km, Europan craters become shallower with increasing size. The anomalous interior landforms associated with these craters (disrupted rims, modified or distorted central peaks, rugged floor topography) indicate that these are NOT relaxed "ordinary" Ganymedean craters, but rather craters whose development was arrested or highly modified during crater collapse. At D >30 km, the primary impact crater no longer exists and the "crater" is essentially "flat". These data suggested that larger craters on Europa form in an unusually weak layer, one that may be underlain by liquid water [1, 4]. Modeling of this collapse by Turtle and Ivanov [5, and this workshop] suggests that the liquid layer may be at least 20 km deep [4]. Although dependent on our limited understanding of impact crater formation and modification processes [5], These data provide an independent and relatively

robust constraint on the thickness of Europa's ice shell.

Conclusions. Impact morphology on the icy Galilean satellites provides important lessons for Titan. Comparison to relatively well understood bodies will be important for understanding any large impact features observed on Titan. Crater depths will be important to determine, as well as mapping of interior landforms and ejecta deposits.

References: [1] Moore et al. (1998) Icarus, 135, 127-145. Moore et al., (2001) Icarus, 151, 93-111. [2] Schenk, P., and F. Ridolfi, (2002) Geophys. Res. Lett. 29, 12, 31. [3] Schenk, P., Chapman, C., Zahnle, K., and J. Moore, (2004) Ages and Interiors, in Jupiter, Cambridge U. Press, in press. [4] Schenk, P. (2002), Nature, 417, 419-421. [5] Turtle, E., and B. Ivanov, (2002) Lunar Planet. Sci. XXXIII, abstract no. 1431.

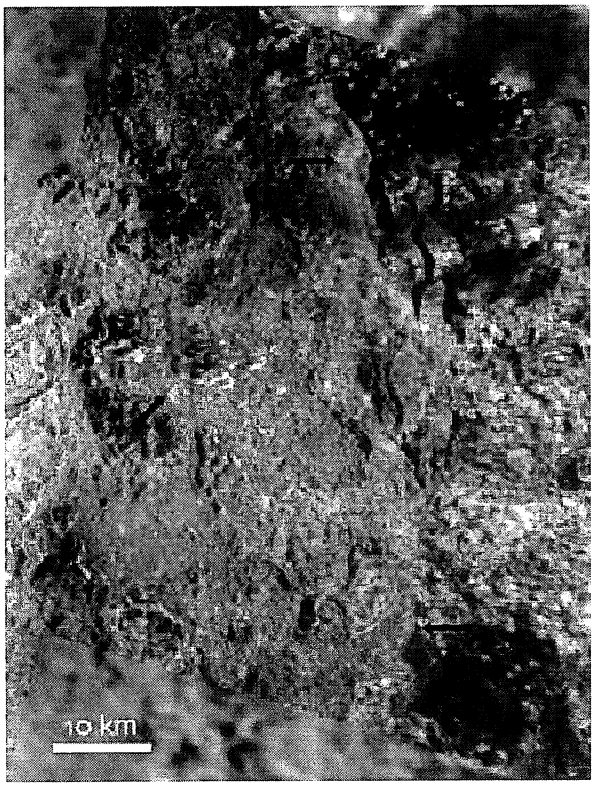

Figure 1. Portion of high-resolution mosaic and stereo DEM (color-coding) of interior and rim of Mananan, Europa. Flow-like features are indicated by arrows.

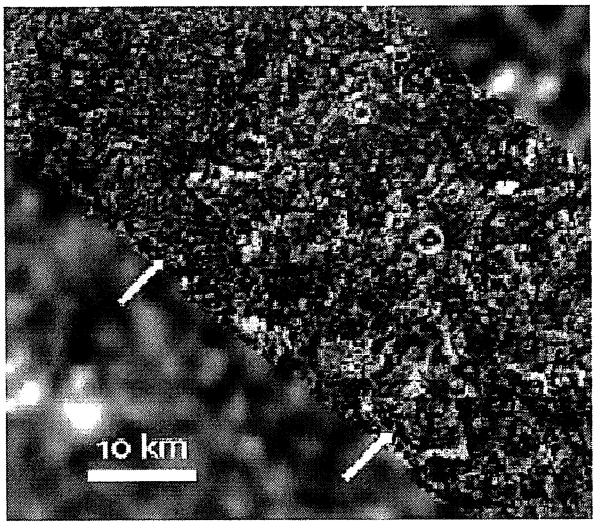

Figure 2. Portion of high-resolution mosaic across Epigeus, Ganymede. Arrows indicate radial flow-like features.